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Caloric Consumption in Industrializing Belgium

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This article provides estimates of Belgian food consumption in 1812 and 1846 using a national food balance sheet approach. These estimates are then converted into caloric intakes for adult male equivalents. Despite many accounts of an absolute pauperization of the Belgian population during this period, caloric consumption per equivalent adult male is shown to have merely stagnated between 1812 and 1846. There is indirect evidence that inequality in caloric consumption increased at the same time. Energy cost-accounting exercises reveal that the residual caloric quantity available for physical exertion was minimal for large sections of the population.

INTRODUCTION

The last decade has seen a revival of the standard-of-living controversy. The paper that brought the debate back to the attention of most scholars was Lindert and Williamson's 1985 recalculation of real wages in Britain, which concluded definitively that real wages increased sharply during the Industrial Revolution beginning in about 1819.[1] Far from settling the debate, however, Lindert and Williamson seem to have rejuvenated it. A number of articles and books have since claimed that if the pessimist camp were going to concede defeat, more than just real wage series would be needed.[2] Moreover, some revisions in specific industry data have cast doubt on the conclusion dating the rise in living standards back to the late 1810s rather than the mid-1840s.[3]

It is not surprising, then, that the history of diets has received renewed interest. In the economic development literature, caloric indicators are often described as the best poverty criteria, and average caloric intake thus appears to be an obvious standard-of-living measure

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[1] Lindert and Williamson, "English Workers' Living Standards."

[2] See, for instance, Floud, "New Dimensions"; Fogel, "Biomedical Approaches"; Komlos, *Nutrition and Economic Development*, pp. 43–50; and Mokyr, "Is There Still Life?"

[3] Brown, "The Condition of England."

for the "developing" countries of nineteenth-century western Europe.[4] Nutrition also plays a key role in the recent marriage of biomedical science and economic history, which is bound to produce a myriad of interesting insights.[5] For example, nutritional improvements are put forward to explain the great mortality decline as well as increases in labor productivity.[6]

Fogel has estimated English caloric consumption in 1790, using the Davies-Eden household consumption studies as analyzed by Shammas.[7] For France there is the monumental study of Toutain, delineating food consumption quantitatively from 1789 to 1964.[8] Quantitative aggregate food consumption studies are still wanting for a lot of countries, however, partially due to a lack of adequate data.

In an attempt to fill in one gap, this article focuses on caloric consumption in Belgium during the first half of the nineteenth century. It is widely believed that this era of the gradual breakthrough of the Industrial Revolution coincided with an absolute pauperization of large sections of the Belgian population.[9] I will attempt to quantify and test this belief by comparing food consumption per equivalent adult male, aged 20 to 39, in 1812 and in 1846.

I first derive per capita food consumption in those years, primarily using the data on Belgian agricultural output that Goossens so carefully collected.[10] I then convert this average into caloric intake per equivalent adult male, combining detailed data on age and sex with Food and Agricultural Organization (FAO) suggestions for energy requirements by age. The third section provides a caloric distribution for both periods. In the next section I offer some further discussion of the results linking them to labor productivity and finally present some concluding remarks.

BELGIAN PER CAPITA CALORIC CONSUMPTION IN 1812 AND 1846

Estimates of mean caloric consumption in Belgium for 1812 and 1846 are reported in Table 1. Those estimates are based on a national food balance sheet, the procedures for constructing which are described in an appendix.[11]

[4] For an example of this view in the development literature, see Lipton, "Poverty, Undernutrition and Hunger."

[5] See especially Fogel, "Biomedical Approaches."

[6] See Mokyr's review essay on the great mortality decline, "Economics, History, and Human Biology"; for labor productivity increases, see Fogel, "Biomedical approaches"; and Mokyr, "Dear Labor."

[7] Fogel, "Biomedical Approaches"; and Shammas, "The Eighteenth-Century English Diet."

[8] Toutain, "La consommation alimentaire."

[9] See, for instance, Lis and Soly, "Food Consumption," pp. 460–86, and *Poverty and Capitalism*.

[10] Goossens, "De economische ontwikkeling."

[11] The appendix is available from the author on request. Its estimates of the food available for

TABLE 1
PER CAPITA NATIONWIDE CALORIC CONSUMPTION IN BELGIUM
(calories per day)

	1812		1846	
Cereals	1,162.7	(58.3)	1,035.3	(51.6)
rye	507.5		410.8	
wheat	362.4		445.4	
Potatoes	238.1	(11.9)	399.6	(19.9)
Dairy produce	321.6	(16.1)	290.0	(14.5)
Meat	177.0	(8.9)	174.8	(8.7)
Fish	7.6	(0.4)	5.4	(0.3)
Pulse	59.2	(3.0)	45.9	(2.3)
Tropical goods	27.7	(1.4)	53.9	(2.7)
Total	*1,993.9*	*(100.0)*	*2,004.9*	*(100.0)*
Beer	219.2		202.1	
Wine	8.6		3.1	
Gin	25.8		28.5	
Total (with alcohol)	*2,247.5*		*2,238.5*	

Source: Figures are based on computations carried out in an appendix available from the author.

The data of Table 1 demonstrate the dominant position of cereals in the daily menu during the nineteenth century. They also indicate a partial shift away from cereals to potatoes. As Vandenbroeke has documented, the potato was food primarily for the rural poor until the last decades of the eighteenth century and was only effectively marketed toward the end of the Ancien Régime.[12] Potatoes were also more prevalent in Flanders than elsewhere in Belgium. In any case, potato consumption in Belgium, even in 1846, was still a far cry from the 1,400 calories per capita per day in potatoes consumed by the Irish at that time.[13] Potatoes, of course, constituted a cheap form of energy supply. Using the price series in Ducpétiaux and the NEVO food composition table, I derive a potato cost of approximately 5 Belgian cents per 1,000 calories in 1844, whereas the same number of calories from rye or wheat bread cost 7 and 9 cents, respectively.[14] Later bad harvests, in 1845 to 1847, drove up the relative potato price and caused a decline in potato consumption.[15] Within the cereals category, Table 1 shows a shift away

human consumption are calculated by subtracting from annual food production the net changes in inventory, net exports, seeds, feed, losses in distribution, and plate waste. The appendix also contains a sensitivity analysis that evaluates the robustness of the main results to varying degrees of measurement error using a small-scale Monte Carlo experiment. For a survey of different historical sources of information on consumption and their limitations, see Fogel, "Biomedical Approaches," sec. 1.2, and the sources cited therein.

[12] Vandenbroeke, "Agriculture et alimentation," pp. 235–89.

[13] See Mokyr, *Why Ireland Starved*.

[14] Ducpétiaux, "Budgets économiques"; and NEVO food composition table, *Nederlands voedingsstoffenbestand*.

[15] The data are not seriously affected by the 1846 crisis because Goossens, in "De economische ontwikkeling," averaged the yield ratios over several years to compute production figures.

from rye to expensive wheat. Both developments confirm at a national level what Lis and Soly observed in Antwerp.[16] They interpreted the switch from rye to potato consumption as a clear sign of the impoverishment of large sections of the people, whereas the rise in consumption of wheat indicates an increase in the number of well-to-do. This simultaneous pauperization and enrichment, ascribed to emerging industrialization, was also observed by Vandenbroeke.[17]

Obviously, Table 1 conceals very important regional differences. The decline of the linen industry severely lowered the living standards of many Flemish families at the same time as, in the south, the emerging metallurgical and mining industries began offering attractive wages.[18] Detailed budget studies on the living conditions of the working classes do reveal some regional differences, but the figures are hard to interpret.[19] Interestingly enough, Ducpétiaux strongly contested the view that workers in the city were better fed than those in the countryside.[20]

Fortunately, it is possible to gain some insight into caloric consumption in some cities. Food consumption studies are available for the cities of Antwerp, Ghent, Brussels, and Bruges.[21] They indicate that in all cities but Brussels per capita consumption was lower than the national average in both 1812 and 1846. Although city people consumed more meat and dairy produce than did rural dwellers, there seems to have been an urban cereal deficiency. Average caloric intake fell between 1812 and 1846 in all cities. Overall, the consumption of meat and alcoholic beverages steeply declined, which is also indicative of pauperization.[22]

It is useful to place the Belgian estimates in a comparative perspective. Toutain, also working with food balance sheets, has provided an extensive overview of caloric consumption in France starting from 1789.[23] Based on his work, I estimate nonalcoholic caloric consumption in France at about 1,700 calories for the decade from 1803 to 1812 and at about 2,250 for 1845 to 1854.[24] In Belgium, major improvement in the living conditions of the masses lagged behind, occurring only in the last

[16] Lis and Soly, "Food Consumption."
[17] Vandenbroeke, "L'alimentation à Gand."
[18] See Ducpétiaux, "Budgets économiques," for evidence on this.
[19] Ibid.
[20] Ibid., p. 281.
[21] For Antwerp, see Lis and Soly, "Food Consumption"; for Ghent, Vandenbroeke, "L'alimentation à Gand" and "Voedingstoestanden te Gent"; for Brussels, Verheydt, "De voedingstoestanden te Brussel"; and for Bruges, De Vos, "De voedingstoestanden te Brugge." I adapted the original data to make the analysis comparable with Table 1. Details of the procedure and a table analogous to Table 1 for the four cities are contained in the appendix.
[22] Vandenbroeke, in "Kwantitatieve en kwalitatieve aspecten," suggests meat consumption as a reliable indicator of social welfare in the nineteenth century.
[23] Toutain, "La consommation alimentaire."
[24] My appendix contains a table analogous to Table 1 and details on the derivations. The significant increase in caloric consumption is puzzling but should be interpreted with care, as Toutain's method was in some instances rather sketchy.

quarter of the nineteenth century.[25] Another striking difference concerns the composition of the diet. The French diet depended even more on cereals, and the potato had still not become a major component of the daily menu at midcentury.

Comparable data for England are not available. Shammas reported the daily caloric intake per inmate of eighteenth-century poorhouses to range between 2,000 and 2,500.[26] She also studied the Davies-Eden budget surveys, but the samples were small and definite conclusions cannot be drawn from them.

For Germany, a detailed reconstruction such as was done for France likewise proved impossible. Lemnitzer did give useful indications.[27] He estimated caloric consumption per head to be 2,210 at the end of the eighteenth century and 2,121 from 1850 to 1854. Germany's diet also underwent a marked shift from cereals to potatoes. The big upward push in caloric consumption came only in the second half of the nineteenth century. Thus, the German caloric situation resembled that of Belgium in many ways.

Table 1 reflects the monotonous diet of the average citizen in nineteenth-century Belgium. It also suggests that the caloric content of that diet was not at all high. Calories can actually serve as a poverty measure, and in the current development literature insufficient calorie intake is judged more reliable than protein deficiency as an indicator of problems in developing countries.[28] Undernutrition usually signals an insufficient intake of specific nutrients such as proteins, minerals, and vitamins, whereas adequate caloric intake normally eradicates protein deficiency, thus subsuming that criterion.[29] Both the per capita levels of caloric consumption and the cereal-based dietary pattern in nineteenth-century Belgium seem similar to those observed in today's developing countries.[30] Hungry or undernourished people there receive too few calories because they are poor. The next section will try to give a more clear-cut answer to the question of whether the burgeoning industrial society in Belgium made people better or worse off.

BELGIAN CALORIC CONSUMPTION PER EQUIVALENT ADULT MALE

The per capita figures derived above constitute a useful basis for neither international nor intertemporal comparison, simply because

[25] See Vandenbroeke, "L'alimentation à Gand"; and Goossens, "De economische ontwikkeling."

[26] Shammas, "The Eighteenth-Century English Diet."

[27] Lemnitzer, *Ernährungssituation*.

[28] See Lipton, "Poverty, Undernutrition and Hunger"; Reutlinger and Selowsky, "Malnutrition and Poverty"; Schmitt, *Protein, Calories and Development*; and FAO, "Fourth World Food Survey."

[29] Moreover, if protein requirements are met but energy requirements are not, some of the protein intake will be used as a source of energy and the diet will end up deficient in protein as well.

[30] See Schmitt, *Protein, Calories and Development*; and FAO, "Fourth World Food Survey."

Table 2
CONVERSION FACTOR BETWEEN PER CAPITA CALORIC CONSUMPTION AND CALORIC CONSUMPTION PER EQUIVALENT ADULT MALE

			1812		1846		FC[f]	
AI[a]	RCCM[b]	RCCF[c]	M[d]	F[e]	M	F	1812	1846
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
0–4	0.4413	0.4367	5.94	6.16	5.86	5.78	0.0531	0.0511
5–9	0.7100	0.6667	5.64	5.54	5.52	5.38	0.0770	0.0751
10–14	0.9000	0.8000	5.37	5.17	5.00	4.78	0.0897	0.0810
15–19	1.0167	0.7833	4.58	4.77	4.55	4.44	0.0839	0.2615
20–39	1.0000	0.7333	13.02	15.21	15.18	14.96	0.2417	0.2615
40–49	0.9500	0.6967	5.57	5.51	6.03	5.78	0.0913	0.0976
50–59	0.9000	0.6600	4.17	4.14	3.59	4.22	0.0649	0.0602
60–69	0.8000	0.5867	2.91	2.82	2.54	2.95	0.0398	0.0376
70+	0.7000	0.5133	1.79	1.69	1.60	1.85	0.0212	0.0207
			48.99	51.01	49.88	50.12	0.7626	0.7680

[a] Age intervals.
[b] Relative caloric consumption of males—that is, the average caloric consumption requirement of males at given ages as a proportion of the requirements for males aged 20 to 29.
[c] Relative caloric consumption of females.
[d] Males.
[e] Females.
[f] Factor contribution—that is, column 2 times column 4 or 6 plus column 3 times column 5 or 7.
Sources: For columns 2 and 3, see Fogel, "Biomedical Approaches"; for age and sex distribution in 1812, see my data appendix; for age and sex distribution in 1846, see Heuschling, "Résumé du recensement."

energy requirements vary with age, sex, body weight, and activity level.[31] It is therefore appropriate to standardize for the age and sex distribution of the Belgian population. In Table 2 I derive the factor converting per capita consumption of calories into consumption per equivalent adult male, aged from 20 to 39, using age- and sex-dependent energy requirement ratios computed by Fogel.[32]

It turns out that the conversion factors in 1812 and 1846 hardly differ. For Ghent in 1812, a similar exercise can be carried out on the basis of the demographic study of Jaspers and Stevens.[33] The resulting conversion factor is 0.7564. It is considerably lower than the national average owing to the high proportion of women in the city of Ghent.

Table 3 sums up the available data for the caloric consumption per equivalent adult male. The conversion factor for France (1803–1812)

[31] See Passmore and Eastwood, *Davidson and Passmore Human Nutrition*, pp. 14–22; and FAO/WHO, "Energy and Protein Requirements."

[32] Fogel, "Biomedical Approaches." Ratios like this can also be found in Blanc, *Malnutrition et sous-développement*. Some caveats concerning these methods are discussed in my appendix. The appendix also contains detailed information on how the age and sex distributions were derived. The middle part of this article draws heavily on the methodology developed in Fogel's paper.

[33] Jaspers and Stevens, *Arbeid en tewerkstelling*. The computations are carried out in the appendix.

TABLE 3
CALORIC CONSUMPTION PER EQUIVALENT ADULT MALE IN BELGIUM, FRANCE, AND ENGLAND
(calories per day)

	Per Capita Caloric Consumption	Caloric Consumption per Equivalent Adult Male
Belgium (1812)[a]	2,038.9	2,673.6
Belgium (1846)	2,067.9	2,692.6
Ghent (1812)	1,829.9	2,410.7
France (1803–1812)[b]	1,698.4	2,226.1
France (1845–1854)	2,369.9	3,078.2
England (1790)[c]	n.a.	2,700

[a] For Belgium and Ghent I added an estimate for fruit and vegetables to the numbers computed in Table 1 and the table in my appendix 2. Lacking better data, I simply took Toutain's estimates for France. I did not include vegetable oils in the same way because several sources (for instance, Lis and Soly, "Food Consumption in Antwerp"; and Vandenbroeke, "Agriculture et alimentation") have described the minimal importance of those products in the Belgian diet.
[b] The estimates include fruit, vegetables, and vegetable oils. See my appendix for details on how I adapted Toutain's original data.
[c] See Fogel, "Biomedical Approaches."
Note: n.a. stands for not available.
Sources: For Belgium, Tables 1 and 2; for Ghent, the table in my appendix 2 and the conversion factor computed in appendix 5. The figures for France are based on the table in my appendix 3 and on the conversion factors mentioned in the text. For England, see Fogel, "Biomedical Approaches."

was taken from Fogel.[34] After employing the age and sex distribution derived by Bourgeois-Pichat, the conversion factor for 1851 turned out to be 0.7699.[35] The data reveal that on the average a citizen in Ghent, then the main cotton center of Belgium, was much worse off than the average Belgian at the beginning of the nineteenth century. Furthermore, with the industrial era looming in a lot of countries, nutritional levels in France were still very low.

This, of course, begs many questions. Roughly speaking, English and Belgian laborers could avail themselves of 400 extra calories to do one extra hour of moderate to heavy work per day, compared to a French worker.[36] Did this nutritional deficiency impair productivity and hamper the emulation of the Industrial Revolution in France? Did the higher caloric intake of the Belgian workers make them physically fitter "to withstand the work discipline of the new industries"?[37] Obviously,

[34] Fogel, "Biomedical Approaches," fn. 2.
[35] Bourgeois-Pichat, "The General Development."
[36] See Passmore and Eastwood, *Davidson and Passmore Human Nutrition*, for the energy requirements of moderate work. For the Habsburg monarchy around 1789, Komlos, in *Nutrition and Economic Development*, estimated caloric consumption per adult male equivalent also to be roughly 2,700 calories. For Ireland, Ó Gráda, *Ireland*, has put forward a mean intake of 3,168 calories per adult male consumption unit. This remarkably high estimate is due largely to the potato-based diet of the Irish.
[37] Shammas, "The Eighteenth-Century English Diet," p. 255. By the 1840s Belgium had clearly moved ahead of other continental countries in the coal, iron, and machine industries (see Landes,

further research is needed before such bold hypotheses can be supported. Nevertheless, questions like this are posed in the present day, in the economic development literature. Blanc and Lemnitzer, for instance, have written at length not only about the links between productivity and nutrition but also about the negative effects malnutrition has on psychological behavior and on attitudes toward technological progress.[38] Another question raised by Table 3 is what would be a plausible explanation for the complete standstill of caloric consumption in "industrializing" Belgium.[39] This stagnation is consistent with the view that the "masses in western Europe were on average practically unaffected by the Industrial Revolution," even in England, before the mid-1840s.[40] The estimates for France, however, do show a substantial rise in caloric intake.

But before searching for explanations of the information contained in Table 3, these average caloric intakes deserve further scrutiny. How high or low are they? Equation 1 summarizes our present knowledge about energy requirements.

$$E = a(H, W, K, A, B) + b(L) + c(Y) + \mu \qquad (1)$$

where E is the energy requirement in calories; $a(.)$, $b(.)$, and $c(.)$ are functional forms; and μ is an error term, reflecting individual specific factors not accounted for by H (height), W (weight), K (climate), A (age), B (body composition), L (labor, physical activity), and Y (income).[41]

Luxury consumption is represented by $c(Y)$ and can be ignored for nineteenth-century societies, except for the small group of the upper classes. The most useful exercise in the present context is to carry out "backwards energy cost accounting."[42] After substituting the actual caloric intake for E and calculating the contribution of $a(.)$, we are left with residual energy available for physical activities (the expected value of μ should normally be zero). The $a(.)$ factor is called the baseline energy need and equals 1.27 times the Basic Metabolic Rate (BMR), the

The Unbound Prometheus, *passim*; and Craeybeckx, "The Beginnings of the Industrial Revolution"), and was undoubtedly the most industrialized nation on the continent. However, Robert Fogel pointed out to me that many of the new industries actually required fewer calories per hour of work than did farming.

[38] Blanc, *Malnutrition et sous-développement*; and Lemnitzer, *Ernährungssituation*.

[39] The proportion of the work force engaged in agriculture was still about 50 percent in Belgium at midcentury, but was much higher in France (Landes, *The Unbound Prometheus*, pp. 187–89). The spurt in caloric consumption in "agricultural" France during the first half of the nineteenth century remains in doubt. For criticism of Toutain's estimates, see my footnote 24 and the appendix.

[40] Mokyr, "Dear Labor," pp. 22–23.

[41] For instance, μ will be high for a pregnant or lactating woman; it might be negative for people used to low calorie intakes and/or who were born into poor families. See FAO/WHO, "Energy and Protein Requirements"; and Lipton, "Poverty, Undernutrition and Hunger."

[42] See Fogel, "Biomedical Approaches," pp. 4–7.

energy required to maintain the body while at complete rest.[43] The BMR does not allow for the metabolic response to food and the energy cost of activities such as washing, dressing, and short periods of standing. Taking into account eight hours of sleep, a survival diet for a totally inactive human being takes up 1.27 times the BMR. The remaining task is to determine the dependence of the BMR on factors such as age, weight, climate, body composition, and height. The dependence on climate is irrelevant for the present study but would become crucial for studies on the developing countries.[44] Height, at least for adults, appears to have little effect on energy requirements independently of its relationship to weight. Moreover the effect of body composition, for people in acceptable weight-for-height ranges—the so-called body mass index (BMI) or Quetelet's index, weight/(height)^2, is the common measure for this—is primarily age and sex related. The primary determinants of "baseline" energy requirements are thus body weight and age. After trying out several functional forms, the FAO/WHO committee retained simple linear functions of body weight for several age ranges. Some examples are given in equation 2.

$$\text{(males, 18 to 30)}\ a\ (H,\ W,\ C,\ B) = 1.27\ (15.3\ W + 679) \qquad (2)$$

$$\text{(females, 18 to 30)}\ a\ (H,\ W,\ C,\ B) = 1.27\ (14.7\ W + 496)$$

where the units are kg for W and calories (kcal) per day for the resulting a-value.

Unfortunately, weight data for nineteenth-century people are very hard to come by. However, if I assume that the nineteenth-century male had an acceptable BMI, I can use the "normal" BMI ranges proposed by the FAO/WHO committee to determine the weight from data on heights. For 1851 to 1855, Quetelet estimated the mean height of a 25-year-old man to be 164.5 cm, using data on Belgian military conscripts.[45] Piecemeal information leads me to an estimate of 166 cm for the national average height in 1812.[46] The desirable and/or acceptable

[43] See also ibid., p. 3. What follows draws heavily on FAO/WHO, "Energy and Protein Requirements," which represents the current state of knowledge in energy and protein requirements.

[44] See, for instance, Lipton, "Poverty, Undernutrition and Hunger."

[45] Quetelet, "De la statistique." For an assessment of historical sources of information on heights, see Fogel, "Biomedical Approaches," sec. 1.4. I will not digress on the numerous problems associated with deducing the average population height from military records; I simply take the numbers mentioned in the literature as rough approximations of the truth.

[46] For 1812 data are not readily available. Quetelet, in "Recherches sur la loi," mentioned averages of the height of military conscripts for several counties in the province of Liège (1816) that range between 159.2 cm and 165.1 cm. Roosemont, in "Sociaal-anthropometrische studie," recorded an average height of 165.9 cm for recruits in East Flanders (1805/1806). These numbers do have to be scaled up because recruits, approximately 20 years old, had not fully matured yet. Quetelet, in "Recherches sur la loi," studying heights based on citizens in Brussels (around 1820), noted a height increase for men of approximately 0.6 percent between age 19 and age 25. Even

range put forward by the FAO/WHO committee is 20.1 to 25 BMI. At a BMI of 22, a typical Belgian 25-year-old male would have weighed approximately 60.6 kg in 1812 and 59.5 kg in 1846.[47] Those figures imply that a survival diet would absorb 2,040 calories in 1812 and 2,020 in 1846. This leaves our average man about 600 calories in 1812 and 640 calories in 1846 for physical activities. In fact, this would be merely enough for 5 to 6 hours of light cleaning a day.[48] However, it is sometimes argued that "western" caloric standards are not really appropriate to developing countries and likewise might not be so for a nineteenth-century "developing" country. Lipton claims that the common intake norms overstate the actual requirements in developing countries by at least 20 percent.[49]

This section has shown that living standards in Belgium failed to improve during the first phase of industrialization, but it has not confirmed the view—held by most Belgian historians—that living standards actually declined between the end of the Ancien Régime and 1850.[50] Contemporaries such as Heuschling and Ducpétiaux poignantly depicted the dismal living conditions of the working classes around midcentury.[51] The 1846 census revealed that over 16 percent of the Belgian population was registered in public poorhouses, but, as Heuschling commented, "It would be a big mistake to take the figures recorded in every village as indicators of actual poverty."[52] However, the results from this section clearly indicate that there were as many calories available in 1846 as in 1812, and the increasing importance of potatoes might even have benefited the physical well-being of the Belgian population.[53]

This acute awareness of extreme poverty can only be reconciled with the quantitative evidence if I postulate that, as Lis and Soly and Vandenbroeke suggested, *an increase in inequality* took place.[54] A further analysis of Table 1 corroborates this hypothesis. The shift from

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then, not all of them had reached their final height. The average height found for men at age 25 was 167.5 cm.

[47] Robert Fogel pointed out to me that the BMI might have been lower. Military data on English recruits in 1860, for instance, indicate a BMI of about 20.5.

[48] The BMR per minute of a man in 1812 equals 1.1155. The energy expenditure of light cleaning is 2.7 times the BMR (see FAO/WHO, "Energy and Protein Requirements"), or 3.01 calories per minute, which leads to the statement in the text.

[49] Lipton, "Poverty, Undernutrition and Hunger."

[50] See, for instance, Scholliers and Van Den Eeckhout, "De hoofdelijke voedselconsumptie"; and Vandenbroeke, "Voedingstoestanden te Gent," "L'alimentation à Gand," and "Kwantitatieve en kwalitatieve aspecten"; Lis and Soly, "Food Consumption"; and Goossens, "De economische ontwikkeling."

[51] See Heuschling, "Résumé du recensement général"; and Ducpétiaux, "Budgets économiques."

[52] Heuschling, "Résumé du recensement général," pp. 160–61.

[53] See also Mokyr, "Dear Labor."

[54] Lis and Soly, "Food Consumption"; and Vandenbroeke, "Voedingstoestanden te Gent."

cheap rye to expensive wheat and from expensive cereals to cheap potatoes constitutes prima facie evidence if the shift can be shown to be primarily due to income effects.[55] In fact, an examination of the relevant relative prices over the period from 1807 to 1850 revealed that they were relatively stable, so substitution effects could have played only a minor role.[56] The change in consumption pattern is then consistent with the view that a larger group of wealthy people could now afford to consume wheat whereas poorer sections of the population were forced to subsist on potatoes.[57]

At least part of the income polarization was a widening of income gaps between regions. Evidence on the pauperization of East Flanders can be found in the data for Ghent and the work of Roosemont.[58] He examined records for military recruits for the province of East Flanders in 1805/1806 and in 1846. For most counties the height of the rejected was included, so he was able to avoid the problem of a truncated sample. The average height in 1805/1806 was 165.9 cm; in 1846 this average dropped to 162.1 cm, a very significant decrease.[59] The polarization between rich and poor, which could have driven a large proportion of the population to the lower subsistence levels, is further assessed in the next section.

THE DISTRIBUTION OF CALORIES IN 1812 AND 1846

The distribution of food and calories is of the utmost importance in estimating global calorie deficits in developing countries today.[60] For my purposes a caloric distribution could provide some insight into the living standards of different classes of people and especially of the poor. In the last section I formed an estimate of the mean of this distribution.

[55] Mokyr, in "Dear Labor," p. 30, asserted that potatoes tended to be an inferior good almost everywhere in Europe.

[56] These observations are based on prices quoted on the market in Leuven. See Peeters, "Les prix." Goossens, in "De economische ontwikkeling," mentioned the price homogeneity of different Belgian cereal markets. The price of rye relative to wheat and of potatoes relative to wheat and rye actually sharply increased in 1846 compared with 1812. However, if we compare the "normal" years (see Goossens, "De economische ontwikkeling") 1808–1810 with 1842–1844, we see that the relative potato-to-wheat or potato-to-rye price dropped slightly in 1842–1844 and the relative rye-to-wheat price rose slightly. The five-year averages given in Vandenbroeke, "Werkinstrumenten," actually show higher potato prices relative to wheat for both 1841–1845 and 1846–1850, compared with 1811–1815.

[57] For the diets of different classes of people, see Ducpétiaux, "Budgets économiques." This document also reveals that tropical goods (except for coffee) did not appear on the ordinary man's menu. In that sense, as an anonymous referee suggested, the doubling of their consumption can also be interpreted as support for the polarization hypothesis.

[58] Roosemont, "Sociaal-anthropometrische studie."

[59] For 1846, the average excludes the one county (Oudenaarde) for which the sample was truncated. As this was one of the poorer areas, the numbers here underestimate the height decrease.

[60] See Schmitt, *Protein, Calories and Development*, p. 163; and FAO, "Fourth World Food Survey."

Direct and indirect evidence from the development literature points toward distributions that are skewed, such as the Pareto, lognormal, or certain Beta distributions.[61] My aim was to come up with reasonable distributions for the Belgian caloric situation in both 1812 and 1846. Table 4 shows the results of that attempt.[62]

Table 4(a) presents deciles for a Beta distribution with a mean of 2,685 calories per equivalent adult male and coefficients of variation of 0.25 and 0.30, respectively. The Beta distribution was, for instance, used by the FAO in an effort to determine the extent of undernutrition in developing countries.[63] The Beta distribution categorizes more people in the lower deciles than does the lognormal distribution, but it provides a slightly better fit at the higher end. There are fewer people consuming more than 5,000 calories but more people in the 3,400-to-4,400 range—which is more consistent with the nutritional evidence for the upper classes. The mean of the distribution for both 1812 and 1846 was taken to be the same, because the sensitivity analysis showed the difference in caloric consumption between the two years revealed in Table 2 to be insignificant. Reasonable values for the dispersion of the distribution can also be gleaned from studies on developing countries. As the calorie-income elasticity decreases with income, caloric distributions are substantially more egalitarian than are income distributions.[64] The range of plausible coefficients of variation can be tightened further by considering its implications at the lower and higher end of the distribution. Coefficients of variation below 0.22 would imply that upper-class people lacked the calories to work a full day, whereas coefficients of variation above 0.37 would imply unrealistically high starvation levels.[65] The evidence for 1846, discussed below, seems most consistent with a coefficient of variation of about 0.3. For 1812 there is no reliable outside evidence available on the living conditions of the poor or the rich. However, I hypothesized above that inequality probably rose between 1812 and 1846; to assess the implications of that, I included a more egalitarian distribution in the table. I also show the caloric distribution

[61] For direct evidence from caloric distributions, see, for instance, FAO, "Fourth World Food Survey"; for indirect evidence from calorie consumption functions, see Reutlinger and Selowsky, "Malnutrition and Poverty." For brief treatments of the distributions mentioned, see Mood, Graybill, and Boes, *Introduction to the Theory of Statistics*. The Pareto distribution turns out not to be useful in this case, as a reasonable estimate for the characterizing parameter implies that the variance of the distribution is not defined. The lognormal distribution is very convenient, in that the properties of the normal distribution can be used to derive deciles and the means within those deciles for the caloric distribution. See Aitchison and Brown, *Lognormal Distribution*; and Fogel, "Biomedical Approaches."

[62] Fogel, in "Biomedical Approaches," carried out a similar exercise for France and England at the end of the eighteenth century using the lognormal distribution. A coefficient of variation of 0.3—that is, a medium level of egalitarianism—squared both postulated distributions with piecemeal evidence on the living standards of the very poor and very rich in England and France.

[63] See FAO, "Fourth World Food Survey."

[64] See Reutlinger and Selowsky, "Malnutrition and Poverty."

[65] See also Fogel, "Biomedical Approaches."

TABLE 4
DISTRIBUTIONS OF CALORIES PER EQUIVALENT ADULT MALE IN BELGIUM AND GHENT

(a) Deciles of Beta Distribution

	cv = 0.25 (1812 national) mean = 2,685		cv = 0.3 (1846 national) mean = 2,685		cv = 0.3 (1812 Ghent) mean = 2,420	
Deciles	Bounds	Means	Bounds	Means	Bounds	Means
1st	<1856	1,656	<1,700	1,496	<1,551	1,384
2nd	1,856–2,091	1,979	1,700–1,962	1,837	1,551–1,772	1,666
3rd	2,091–2,280	2,186	1,962–2,181	2,073	1,772–1,961	1,869
4th	2,280–2,454	2,368	2,181–2,388	2,285	1,961–2,141	2,049
5th	2,454–2,626	2,542	2,388–2,597	2,492	2,141–2,325	2,232
6th	2,626–2,806	2,714	2,597–2,817	2,707	2,325–2,522	2,421
7th	2,806–3,006	2,904	2,817–3,065	2,935	2,522–2,745	2,632
8th	3,006–3,249	3,120	3,065–3,366	3,209	2,745–3,021	2,877
9th	3,249–3,596	3,410	3,366–3,795	3,564	3,021–3,423	3,206
10th	>3,596	3,971	>3,795	4,253	>3,423	3,864

(b) Caloric Intervals for Beta Distribution

Intervals	cv = 0.25 (1812 national) mean = 2,685	cv = 0.3 (1846 national) mean = 2,685	cv = 0.3 (1812 Ghent) mean = 2,420
<1,300	0.25	1.22	2.48
1,300–1,600	2.91	5.76	9.51
1,600–2,000	12.59	14.69	20.16
2,000–2,400	21.10	18.89	21.77
2,400–2,800	22.83	18.69	18.26
2,800–3,200	18.50	15.54	12.89
3,200–3,600	11.91	11.24	7.87
3,600–4,000	6.21	7.14	4.17
4,000–5,000	3.59	6.28	2.76
5,000–6,200	0.10	0.53	0.13
>6,200	0.00	0.00	0.00

Notes: cv stands for coefficient of variation. All computations are done within the Gauss software package, which features the incomplete Beta function. The integration needed to find the means was carried out with a Gauss-Legendre quadrature rule, available in the Gauss package.
Source: Author's own computations.

for Ghent in 1812 with a mean of 2,420 calories per equivalent adult male (see my appendix) and a coefficient of variation of 0.3. Table 4(b) groups the same data over caloric intervals. Technical details on the Beta distribution and on the derivation of the deciles are given in an unpublished appendix available from the author.

To help interpret the distribution, I first had recourse to nutritional science to determine a *starvation* and *glut* level of caloric intake. A maximum level of caloric needs can be defined as the energy requirement of a man of unusual stature (about 180 cm, some two standard

TABLE 5
ENERGY REQUIREMENTS GIVEN VARIOUS ASSUMPTIONS ABOUT ACTIVITY LEVEL, BMI, AND HEIGHT

	BMI = 22.5		BMI = 20.1	
	Tall[a]	Average[b]	Tall[a]	Average[b]
Moderate work[c] (9 hours)	4,229	4,169	4,148	4,095
Chopping firewood[d] (8 hours)	3,678	3,502	3,442	3,285
Milking cows[e] (8 hours)	2,886	2,748	2,701	2,578

[a] Tall equals one standard error (see supra) above average height—that is, 172 cm.
[b] Average equals average height—that is, 165 cm.
[c] Requires 5.5 kcal/minute (Passmore and Eastwood, *Davidson and Passmore Human Nutrition*).
[d] Requires 4.1 times the BMR/minute (FAO, "Fourth World Food Survey"); the BMRs/minute are 1.1630, 1.1079, 1.1033, and 1.0530, respectively.
[e] Requires 2.7 times the BMR/minute (FAO, "Fourth World Food Survey").
Note: For the computations, I assumed (as elsewhere in this article) 8 hours of sleep and took the energy requirements of the nonworking hours (excluding sleep) to be 1.4 times the BMR (see also Fogel, "Biomedical Approaches").
Source: Author's own computations. I would like to thank Robert Fogel for pointing out errors in these computations in a previous draft.

errors above average height[66]) who reaches energy balance at the higher end of the normal BMI range, say 25. If this man were to toil a full eight hours per day, he would need some 5,750 calories.[67] Calorie consumption in excess of this glut level is very unlikely, accountable for only by waste or extreme gluttony. This criterion does not disqualify any of the distributions depicted in the table. Similar reasoning yields appropriate values for caloric consumption in the highest deciles. Energy expenditures associated with various full-day activities are summarized in Table 5.

In comparing Table 5 with Table 4, we must bear in mind that people also got on the average some 10 percent of their calories from alcoholic beverages (see Table 2), which are not included in Table 4. Also, as the energy requirements pertain to continuous, uninterrupted work, they can represent a whole day of labor, sitting, eating, washing, and so on. Thus, the caloric consumption of the upper echelons, implied by the specified distribution, seems quite reasonable.

To judge the plausibility of the lower deciles, I similarly defined a starvation level of calorie intake. The baseline energy need of an adult male with a standard BMI (22) and average height (165 cm) is approximately 2,025 calories. The distribution specification then implies that more than 20 percent of the Belgian population did not attain this basic energy level, bringing most of them to the verge of starvation. Even the

[66] As an approximation for this I took the standard error estimated for Dutch recruits in 1865, namely 7.41 cm (see Fogel, "Biomedical Approaches").
[67] Similar computations will be carried out several times in this and the next section. Weight is determined from BMI and height and is inserted into equation 2. Energy expenditures for heavy work are taken from Passmore and Eastwood, *Davidson and Passmore Human Nutrition*; they amount to 8.7 kcal per minute.

more egalitarian distribution would entail an outrageously high number of literally starving people.

But the above computed basic energy need is not an appropriate starvation level for nineteenth-century Belgium. As mentioned earlier, imposing western standards of nutrition and health on developing countries has increasingly come under attack—and nineteenth-century Belgium is comparable to the latter. Nutritionists now widely accept the view that people faced with severe limitations of food supply display various forms of adaptive behavior.[68] A well-documented behavioral response is a marked decrease in physical activity, which I will come back to in the next section. Another well-known response, already incorporated in my computations, is a decrease in body size, especially stunting. In addition, there is substantial interindividual variation in energy requirements, often as a metabolic adjustment to the economic environment. In its 1985 study, the FAO deemed the range of metabolic adaptation to be small, at most on the order of 15 percent below the reference values. But Lipton took a more radical stand. He ascribed part of the marked correlation between energy intake and energy requirements in the developing countries to the "inherited ability to thrive at low intakes." In families that have been extremely poor for generations, the evolutionary process might select genes resulting in appropriate fat-to-lean ratios and other physical adaptations permitting survival on low-calorie diets. Another study also mentions the capability of large groups of people in developing countries to subsist on diets far below the official FAO requirements.[69] These considerations justify the adoption of a starvation energy level of about 1,300 calories, much lower that the one computed above. This corresponds to the BMR of a person approximately one standard error below average height with an "adaptive" BMI of about 18.[70] People with intakes below that level not only lack the strength to perform any physical activity but simply cannot survive for long, as their energy inputs are near or below basic metabolic requirements. In short, they starve.

By that standard, slightly more than 1 percent of the Belgian population must have been literally starving to death around 1846 (see Table 4). Fogel found the proportion of French below basic metabolism, which he put at 1,250 calories, to be 2.48 percent, whereas the English counted 0.66 percent of their population below that level. He argued that part of the difference in crude death rates between the two countries

[68] See Lipton, "Poverty, Undernutrition and Hunger"; Payne, "Malnutrition and Human Capital"; FAO, "Fourth World Food Survey"; and Fogel, "Biomedical Approaches."

[69] FAO, "Fourth World Food Survey."

[70] This was the BMI of Indian people in 1970, according to Fogel ("Biomedical Approaches," p. 20). The starvation level can also be viewed as the baseline energy need of a person on a subsistence level, displaying extreme adaptive behavior in the Lipton sense (for instance, height two standard errors below average, maintenance factor 1.2 instead of 1.27, BMI of about 17, and final energy requirements 15 percent less than FAO standards).

(38 percent versus 26.8 percent) might result from people literally starving. The crude death rate in Belgium in 1846 was even slightly lower than the death rate in England in 1790, so the distribution specification is certainly not implausible in that respect.[71] Duchêne and Lesthaeghe noted large regional differences in mortality rates: for one thing, they were higher in Flanders than in Wallonia, even in 1812.[72] The higher starvation rate in Ghent (see Table 4), then, comes as no surprise.[73]

For 1846 some other evidence on the calorie intakes of certain classes is available. Bauters studied food consumption in an elite boarding school in Melle, a village near Ghent.[74] These students have to be ranked in the upper deciles, as the annual fee amounted to twice the annual wage of an average worker. In 1846 the students consumed an adult male equivalent of 3,460 calories (including beer and wine, 3,780 calories). This is probably an underestimate, but in any case this study seems to be in accord with the specified distribution.[75]

Ducpétiaux, in his "Budgets économiques," a summary of an extensive inquiry into the living standards of the industrial and agricultural work force of that time, provided some sketchy evidence on the diets of the affluent as well. For instance, he mentioned the amount of bread, potatoes, meat, and butter consumed by a well-to-do rentier. Together they yield some 2,720 calories. Assuming that this rich person consumed double the national average of the other products (fish, tropical goods, vegetables, eggs, and milk—and probably also of poultry, game, and so on), the final caloric intake still only adds up to 3,340 calories, a reasonable but somewhat low figure for somebody presumably in the highest decile.

The monumental "Budgets économiques" also contains price series, which, combined with wage data assembled during the 1846 industrial census, allowed me to infer the approximate cost and affordability of some lower-class diets.[76] The budgets reveal that the diet of the lower classes in midcentury Belgium primarily consisted of rye bread, buttermilk, and potatoes. Bacon was served only occasionally in some families. In Table 6(a) I derive the cost of three low-calorie diets for two types of family. The family with four children is the one used in the

[71] The death rate was 24.8 per thousand, which I computed from Quetelet, "De la statistique."

[72] Duchêne and Lesthaeghe, "Essai de reconstitution."

[73] Admittedly the connection between mortality and nutrition is somewhat controversial, and the actual cause of death might be related only indirectly to insufficient caloric intake.

[74] Bauters, "Voedingspatroon van een internaatspopulatie."

[75] I took some imprecise information on the age distribution of the pupils and staff into account to get a conversion factor like that of Table 2. Calorie values are as in my appendix. The estimate for fish is the minimum one suggested by Bauters. Fruit and vegetables consumption is likewise underestimated, as I used the national average in Table 1.

[76] The industrial census is discussed in Heuschling, "Résumé du recensement général"; and Ducpétiaux, "Budgets économiques." Such an affordability exercise was suggested by Shammas in "The Eighteenth-Century English Diet."

TABLE 6
APPROXIMATE COST AND AFFORDABILITY OF SOME LOWER-CLASS DIETS

(a) Cost in Belgian Francs of Various Amounts of Calories

	2,000 kcal	2,500 kcal	3,000 kcal
Cost per male unit[a]	0.287	0.358	0.430
Cost per family of four[b]	1.012	1.265	1.518
Cost per family of six[c]	1.321	1.651	1.981

(b) Proportion of Income Spent on Food for Family of Four (of Six, in Parentheses)

	Income	2,000 kcal diet	2,500 kcal diet	3,000 kcal diet
Linen worker[d]	1.537	65.84	82.30	98.76
		(85.95)	(u.a.)	(u.a.)
Average industrial worker[e]	3.087	32.78	40.98	49.17
		(42.79)	(53.48)	(64.17)
Agricultural laborer[f]	2.055	49.25	61.56	73.88
		(64.28)	(80.35)	(96.40)
First-tier industry worker[g]	0.986	u.a.	u.a.	u.a.
		(u.a.)	(u.a.)	(u.a.)
Second-tier industry worker[h]	1.562	64.80	81.00	97.21
		(84.59)	(u.a.)	(u.a.)
Median industry worker[i]	2.467	41.02	51.28	61.53
		(53.55)	(66.92)	(80.30)

[a] The diet consists of 60 percent rye bread, 20 percent potatoes, and 20 percent buttermilk. The prices used are 0.210, 0.085, and 0.120 (all francs per kg or liter), respectively; they are based on prison report and market data (see Ducpétiaux, "Budgets économiques," pp. 398–400). The prison report data were marked up by 15 percent, as suggested by Ducpétiaux.

[b] Children are a boy and girl of age 12. The data in Table 2 are used to calculate a conversion factor, which ended up being 3.533.

[c] Children are aged 16, 12, 6, and 2: the prototype family used in the "Budgets économiques." I took the conversion factor to be 4.61, an average of the ones resulting from various possible combinations of ages for two boys and two girls in the family.

[d] Heuschling, "Résumé du recensement," p. 160. For all income computations that follow I assumed two children, a boy and a girl, to be working. As in Heuschling, "Résumé du recensement," and Ducpétiaux, "Budgets économiques," I converted the daily wages assuming 300 working days in a year.

[e] Ducpétiaux, "Budgets économiques," p. 395, based on the census data.

[f] Wages taken from Ducpétiaux, "Budgets économiques," p. 397. I imputed 60 cents of income per day to the children.

[g] Based on wage distribution in Heuschling, "Résumé du recensement," which was derived in turn from the industrial census. According to this source, some 9 percent of adult male workers in the industry earned less than 50 cents a day. More than 36 percent of female workers and more than 60 percent of children earned less than 50 cents a day. A more or less representative wage for families in this range could be approximately 1.20 francs a day.

[h] See note g: 17.1 percent of the adult male industrial work force earned between 50 cents and 1.50 francs a day. Family income for such a group was put at 1.90 francs a day.

[i] The median income for adult males fell toward the high end of the 1- to 1.5-franc range. Women almost always earned less than 1 franc a day, children rarely more than 50 cents. A very rough estimate of the median income of a family working in the industrial sector would be 3 francs.

Note: u.a. stands for unaffordable.

Sources: Author's own computations, based on the information in Ducpétiaux, "Budgets économiques," and Heuschling, "Résumé du recensement."

"Budgets économiques" and should be considered the more typical. In Table 6(b) I compare income with the cost of those diets for some exemplary families. I have throughout assumed that the two oldest children also work and bring in some income. In this sense, the income figures are overstated. On the other hand, some families supplemented their real income by growing food crops themselves.

Assuming that some 20 to 30 percent of total income was devoted to nonfood expenses, families in the linen industry could hardly afford a basic 2,000 kcal diet.[77] Linen workers most certainly were at the bottom of the income range, and my earlier calculations illustrate what kind of hardship this created. Agricultural workers, when not fed on the job, were hardly better off. A large family could barely afford a 2,500-calorie diet. Heuschling has provided a rough wage distribution for the industrial sector, drawing on daily wage data from the 1846 industrial census.[78] Due to underreporting and the registration period, those wages have to be seen as minimal.[79] The incomes of the first-tier, second-tier, and median industrial workers in the table were based on this distribution. Despite their shortcomings, the census data suggest that at least 5 percent of families in the sample had less income than the first-tier industrial family and had to make do with true subsistence diets. Some 15 to 20 percent earned no more than what is specified for the second-tier worker.

The table corroborates the picture of the Beta caloric distribution with a coefficient of variation of 0.3. At the low end a group of beggars and paupers were constantly fighting starvation, even too impoverished to register in public relief houses.[80] But also hard-working families, be they agricultural workers or workers in waning industries such as linen or leather manufacturing, faced severe hardship and were probably undernourished.[81] The bulk of the agricultural laborers and the lower echelons of the industrial proletariat probably made up the lower fourth to fifth deciles of the distribution. As Table 6 illustrates, some industrial workers must have made a decent living and could easily afford 2,500—even 3,000—kcal and more. Workers in the glassworks, coal mines, and the metallurgical sectors earned more than twice as much as workers in the linen industry.

All in all, the Beta caloric distribution with a coefficient of variation of 0.3 seems to be consistent with the piecemeal evidence I marshaled for 1846. The unpublished appendix to this article also compares the caloric situation in nineteenth-century Belgium with that of current developing countries. Depending on the distribution chosen, the proportion of

[77] For evidence on cost of food in proportion to total expenses, see Ducpétiaux, "Budgets économiques," *passim*.

[78] Heuschling, "Résumé du recensement général."

[79] Ibid.

[80] Ibid., p. 160.

[81] See Ducpétiaux, "Budgets économiques," p. 394.

people consuming less than 1,875 calories, which is the undernutrition threshold the FAO specifies, ranges between 9 and 16 percent. This is comparable to the low end of what the FAO records today for many developing countries.

Last, the more egalitarian distribution with a coefficient of variation of 0.25 shows the implications of the likely polarization that took place between 1812 and 1846. Despite the same limited average national supply of energy, the second distribution includes considerably more people in near-subsistence caloric intakes (compare the percentage of people consuming less than 1,300 and 1,600 calories), thus aggravating the poverty problem.

The gradual industrialization of Belgium during that period offers a plausible explanation of this phenomenon. The Industrial Revolution was no smooth process. Wilting industries in certain areas resulted in unemployment and severe wage cuts, whereas emerging industries raised the living standards of other, more fortunate families. The regional distribution of this social and economic upheaval leaves some hope for quantifying this theory. Declining industries such as the linen industry were primarily located in the north of the country (Flanders). At the same time, new industries such as metallurgical factories mushroomed in the south, in Wallonia, creating a wealthier working class there. In "Budgets économiques," the reporter for the southern province of Liège raved about the beneficial impact mechanization had on the apparel consumption of the working class. Accounts of communities in Flanders had no room for optimism. It seems likely that a regional analysis would reveal a sharply different evolution of living standards in these regions.[82]

CALORIES AND PRODUCTIVITY

In 1853, in the conclusion of his "Budgets économiques," Ducpétiaux linked the bad health and declining height of the working classes to insufficient food intake. He also realized that undernutrition impaired the productivity of Belgian workers and put them at a disadvantage compared with, say, English and American workers. He complained continually about stagnating wages and the rising prices of necessities, urging the authorities to take action.

The idea of linking wages, nutrition, and productivity was formalized by Leibenstein in 1957, and the notion of wage-dependent productivity lives on in the efficiency-wage literature. Low wages limit the number of affordable calories, thus hampering physical productivity directly but also indirectly, by depressing learning skills, increasing diseases and

[82] Goossens, in "De economische ontwikkeling," shared this view with me.

absenteeism, inducing lethargy and low mental performance, and so on.[83] Low productivity then prevents wage raises. To break this vicious circle higher wages are called for.[84] Obviously, Belgium in the nineteenth century faced a nutritional constraint as well. A simple example of backward energy cost accounting can illustrate this. The median caloric intake in Belgium was about 2,572 calories per adult male. A typical Belgian worker of average height (165 cm) with a low BMI of 19 would have some 700 calories available for work per day. Assuming 250 days in the work year, this gives him the physical strength to perform on the average little more than four hours of heavy work per day.[85] Although this might not sound very restrictive, one has to realize that 50 percent of the population did not have access to that many calories. The caloric distributions of Table 4 showed that some 20 percent of the population had intakes of less than 2,000 calories. Even when modern energy requirements are adjusted downward to take "adaptive" behavior into account, it is clear that those people lacked the physical energy to enter the work force on a permanent basis.

Belgium was only able to break out of this poverty trap by the end of the nineteenth century. Fogel, in his analogous work on France and England, drew the obvious conclusion that the increased supply of calories after the advent of the Industrial Revolution must have made a nontrivial contribution to per capita growth rates. Not only did it bring the ultrapoor into the labor force and increase the energy available for work by those already working, but also it reduced sick days, enhanced morale, and so forth.

The nutrition-productivity relationship also sheds some light on regional differences in caloric intake levels. If a society faces a nutritional constraint, rational employers should pay "efficiency wages" above the neoclassical market clearing rate, because higher wages will increase productivity. A clear prediction of this model is that rational employers will, if possible, feed workers on the job to ensure their nutritional well-being. And regional differences in pay methods did exist in Belgium in 1846. According to Ducpétiaux, the widespread phenomenon of feeding agricultural workers on the farm was far more common in Flanders, where this practice was recorded in more than 50 percent of the villages during the census.[86] In Wallonia, in contrast, this custom

[83] See Leibenstein, "The Theory of Underemployment"; Schmitt, *Protein, Calories and Development*; Blanc, *Malnutrition et sous-développement*; Lemnitzer, *Ernährungssituation*; and Dasgupta and Ray, "Inequality."

[84] Schmitt, in *Protein, Calories and Development*, successfully applied this "cyclo-nutrition" theory by using variables indicating the nutritional status of agricultural labor in production functions of various agricultural commodities in the developing countries.

[85] The assumption on the number of work days per year was also made in Fogel, "Biomedical Approaches." The calorie requirements are from Passmore and Eastwood, *Davidson and Passmore Human Nutrition*.

[86] Ducpétiaux, "Budgets économiques," pp. 397–98.

prevailed in less than 15 percent of the villages. This is consistent with our theory of regional disparities, with the nutritional constraint being less binding in Wallonia.

CONCLUSION

Despite various accounts of increasing pauperization of the Belgian population during the first half of the nineteenth century, I found that the total supply of calories remained unchanged. The Belgian economy clearly faced a nutritional constraint. Productivity levels of large sections of the population living close to subsistence levels were severely impaired by low energy inputs. Many families relied on public charity to survive. Emerging industrialization, instead of removing the nutritional constraint, may have initially aggravated it by making the income and caloric distribution more unequal and hence the poverty problem more acute. In other words, the Belgian experience, as did the English and American evidence, might confirm the Kuznets hypothesis: inequality in the industrialized countries rose during the early stages of development before falling in the twentieth century.[87] However, the piecemeal evidence I have provided for this theory is far from conclusive. Additional quantitative material—for instance, income distributions, height data, and poor relief data—needs to be examined. Although this might prove infeasible, a regional analysis of living standards for Flanders and Wallonia would greatly enhance our understanding of the way the Industrial Revolution in its early phases affected the living conditions of the Belgian population.

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[87] See Polak and Williamson, "Poverty, Policy and Industrialization."

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